

April 6, 1948.

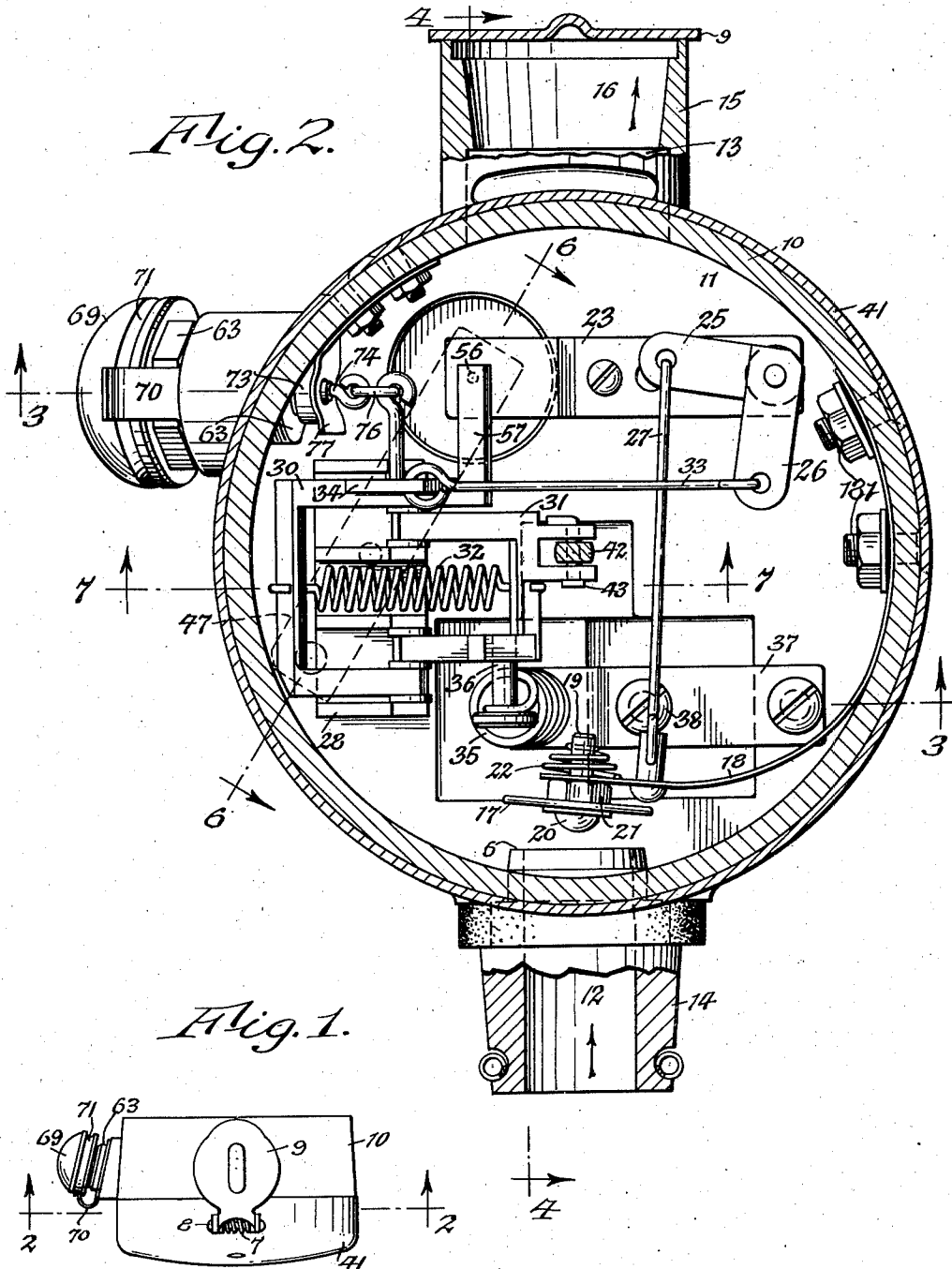
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2,439,016

BREATHING APPARATUS

Filed Oct. 19, 1943

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

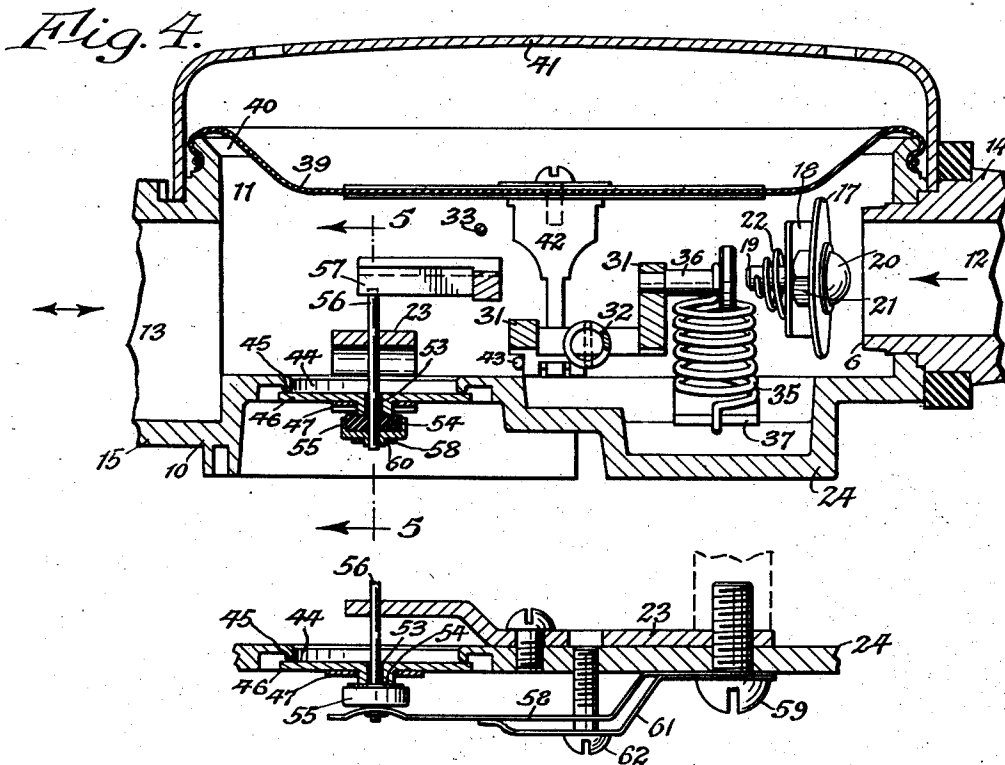
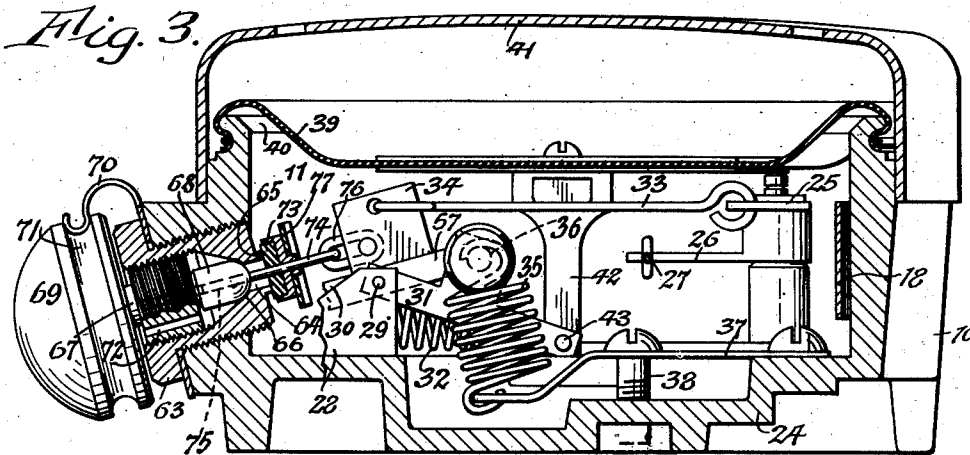


Fig. 5.

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3 Sheets-Sheet 3

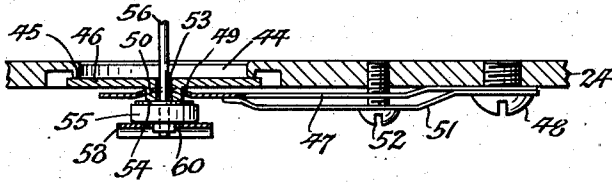


Fig. 6.

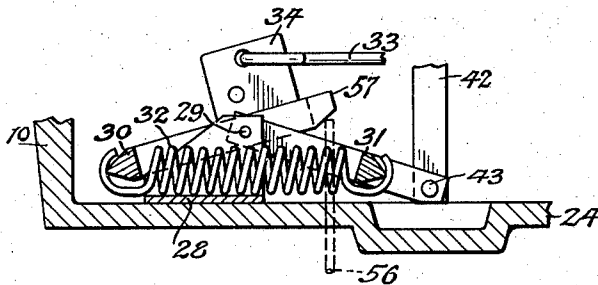


Fig. 7.

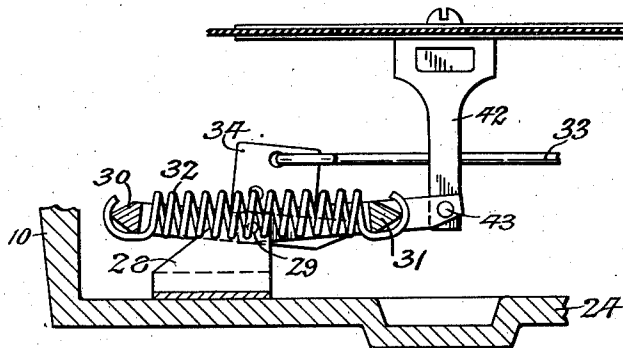


Fig. 8.

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2,439,016

BREATHING APPARATUS

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14 Claims. (Cl. 128—142)

1

This invention relates to a breathing apparatus or resuscitator for aiding or reviving persons whose breathing has either been impaired or arrested at ground level or at a high altitude.

Difficulty in breathing or cessation of breathing is experienced by persons at ground level due to shock or other conditions which affect persons unfavorably and it is also experienced by aviators when flying at high altitudes where the oxygen content of the air is low.

An apparatus of this character should be comparatively light, small and portable so that it is readily available as a resuscitator which can be used advantageously in oxygen therapy at low altitudes and ground level and also used at extremely high altitudes for maintaining useful consciousness where oxygen equipment operating at the prevailing barometric pressure has heretofore failed to provide sufficient oxygen to sustain life for more than a few minutes.

The object of this invention is to provide a portable resuscitator which is light in weight, simple and compact in construction, and dependable and uniform in operation at extreme temperatures and barometric pressures.

With a view of overcoming the foregoing objections and securing certain advantageous results the present invention provides an apparatus which embodies these improvements.

The apparatus functions to produce a changing pressure inside the lungs and thus provide an artificial method of ventilating the lungs. If the user is unconscious, the apparatus functions automatically. If, however, the user is conscious, or should begin to breathe, the apparatus does not exert any rhythm of its own but instantly follows the most minute effort of the user.

The apparatus is a sensitive valve regulating mechanism operating at a low pressure oxygen supply at altitudes, or either oxygen or atmospheric air at ground level. Incoming gas is automatically valved so that an intermittent positive pressure is supplied to the user. Two separate functions, inspiration and expiration, are controlled by the use of intermittent positive pressure. On inspiration low pressure oxygen is allowed to enter the apparatus and pass into the face mask. The gas is permitted to flow until a predetermined pressure is built up inside the apparatus during which time the user becomes inflated to a safe maximum pressure. On reaching the predetermined pressure the regulating diaphragm assembly operates the valving mechanism, stopping the incoming gas and opening other ports to permit the pressure to drop to a

2

pressure nearly that of the atmosphere surrounding the apparatus. If the user is conscious and starts another inspiration, the pressure inside drops to a low critical positive pressure at which point the regulating diaphragm again closes the outlet ports and opens the inlet valves to the incoming gas. If the user is unable to create any inspiration effort, the pressure is automatically reduced to the critical low by a bleed valve adjusted to reduce the pressure inside the regulator to the critical low positive pressure. Life can be maintained with between 4 and 10 automatic cycles per minute. Normal conscious users breathe more than 10 cycles per minute. In this manner the apparatus follows the normal user and functions automatically at a cycle sufficient for maintaining life of the distressed person.

This apparatus will maintain life of unconscious victims at extremely high altitudes by furnishing pure oxygen and creating the necessary ventilation in the lungs. At altitudes of more than 42,000 feet pure oxygen at the pressure of the surrounding atmosphere is not sufficient for life. The positive pressure intermittent regulator of this apparatus maintains useful consciousness 5000 feet to 8000 feet beyond this limit. Used as a positive pressure regulator at ground level this invention has many unusual uses in oxygen or atmospheric air therapy. Positive pressure is the most desirable method of treating war or industrial gas victims, pneumonia, and other respiratory diseases.

From the foregoing it will clearly appear that this invention not only is useful in furnishing oxygen to a person requiring the same but may also be employed in administering other helpful gases to a person requiring the same, such, for instance, as patients requiring a mild form of therapeutic gas, like chlorine, and it is therefore to be understood that in the following description oxygen will be referred to generally for convenience in description but this term is intended to include any other gas which would be beneficial to persons for maintaining life and health.

In the accompanying drawings:

Fig. 1 is a top plan view of the apparatus embodying this invention.

Fig. 2 is a vertical cross section of the same, on an enlarged scale, taken on line 2—2, Fig. 1.

Fig. 3 is a horizontal section, taken on line 3—3, Fig. 2.

Fig. 4 is a vertical section, taken on line 4—4, Fig. 2.

Fig. 5 is a fragmentary section, taken on line 5—5, Fig. 4.

Fig. 6 is a fragmentary section, taken on line 6—6, Fig. 2.

Fig. 7 is a fragmentary section, taken on line 7—7, Fig. 2 and showing the toggle mechanism in a position in which the diaphragm is moved inwardly and oxygen is admitted to the respiration chamber.

Fig. 8 is a similar view showing the toggle mechanism in a position in which the diaphragm is moved outwardly and the oxygen intake valve is closed.

In the following description like reference characters indicate the same parts in the several figures of the drawings.

In general this invention comprises an automatic intake mechanism whereby oxygen is transferred periodically from a source of a supply into a respiration chamber, and an automatic respiration mechanism whereby live oxygen is positively delivered from this chamber to a person and also permitted to freely vent from said person and chamber to the atmosphere during each cycle of operations.

The numeral 10 represents the body or housing of the apparatus which may be of any suitable form but preferably has the general shape of a cylinder and provided within its perimeter with a respiration chamber 11 having an oxygen inlet or intake opening 12 on its underside, a service opening 13 adapted to be connected with the person to be served, and a vent outlet adapted to communicate with the outer atmosphere. The intake port or opening 12 is formed in a tubular plug or neck 14 which is adapted to be coupled by any suitable means with a source of oxygen which is supplied under a slight pressure. The service opening or gas outlet 13 is formed in a neck 15 containing a tubular socket 16 which is adapted to receive the coupling nozzle of a hose or tube forming part of a mask which is applied to the face of a person so as to permanently communicate with his mouth and nose or breathing system. When the apparatus is not in use the service or respiration opening 13 is closed by a lid 9 which is connected on one side of its edge by a hinge 8 to the neck and yieldingly held in its closed position by a spring 7 so as to exclude foreign matter from the interior of the instrument, as shown in Figs. 1 and 2.

The flow of oxygen into the respiration chamber is controlled by an air intake valve mechanism which preferably includes an annular valve seat 6 arranged within the respiration chamber around the inner end of the intake port or opening 12, and a disk-shaped valve or closure 17 arranged within this chamber and movable toward and from the seat 6 for opening and closing the port 12. This intake valve is mounted on the free end of the curved leaf spring 18 which is secured at its fixed end by bolts 19 to the inner side of the adjacent part of the body 10, as shown in Fig. 2. In order to permit the intake valve to swivel or tilt on the supporting spring 18 and thus adapt itself to the seat 6 for fully engaging the same with a leak-tight fit when closed, this valve is connected with the spring 18 as follows:

The numeral 19 represents a bolt passing inwardly through an opening in the disk valve 17 and also loosely through an opening in the free end of said spring and having a head 20 at its outer end which bears against the outer side of the disk valve. A screw nut 21 is applied to the bolt 19 between the disk valve 17 and the sup-

porting spring 18 and the several parts are yieldingly held assembled and in centralized position relative to each other by a spiral centering spring 22 surrounding the bolt 19 and having its inner end secured thereto while its outer end bears against the inner side of the supporting spring 18. By these means the valve 17 is free to rock on the supporting head and engage squarely with the seat 16 so as to form a tight joint therewith but the disk will always remain in a position in which it can freely engage its seat.

Operating means are provided for alternately actuating the intake valve so as to close the same when the pressure within the respiration chamber reaches a predetermined pressure and to open this valve when the pressure within this chamber drops to a predetermined point. In their preferred form these operating means are constructed as follows:

The numeral 23 represents a supporting bracket secured horizontally to the upper part of the inner side of the rigid transverse wall 24 of the respiration chamber. Upon this bracket is pivoted an elbow lever which turns in a vertical plane crosswise of the respiration chamber and is provided with an upper horizontal arm 25 and a lower vertical arm 26, as shown in Fig. 2. The upper arm 25 is connected by a rod 27 with the spring arm 18 which supports the oxygen intake valve 17 so that a rocking movement of the elbow lever will cause this valve to be opened and closed. The lower arm of the elbow lever is operatively connected with a toggle mechanism forming part of the means whereby the intake valve is held at rest during successive periods of time in open and closed positions and to shift quickly from one of these positions to the other during successive cycles of the operation of this apparatus. In its preferred form this toggle mechanism is constructed as follows:

The numeral 28 represents a supporting bracket secured to the inner side of the wall 24 about midway of its height. Upon the inner part of this bracket are mounted, by a pivot pin 29, the opposing ends of outer and inner toggle members 30, 31 each of which is preferably of substantial U form and has the inner ends of its arms overlapping those of the other toggle member, as shown in Fig. 2. The numeral 32 represents a snap spring which is connected at its opposite ends with the outer parts of the toggle members 30, 31 and adapted to move bodily back and forth from one side of the axis 29 of these toggle members to the other and hold these members temporarily in a folded position on either side of this axis during successive cycles in the operation of this apparatus. As shown in Fig. 7 the toggle members are folded or inclined outwardly relative to the wall 24 of the respiration chamber and the snap spring 32 is arranged bodily below the axis 29 of the toggle members and tends to hold these members yieldingly in this position. Upon turning the toggle members inwardly or away from the wall 24 the same are folded inwardly or toward each other on the opposite side of the axis 29, and during this movement the snap spring 32 is first stretched to a greater extent as it approaches this axis and then contracts and folds the toggle members above this axis, as shown in Fig. 8, and retains them yieldingly in this position. Upon turning the toggle members outwardly from the position shown in Fig. 7 to the position shown in Fig. 8, the action of the snap spring will be reversed. This action of the toggle members and the move-

5

ment of the snap spring from one side of the toggle axis 29 is repeated at intervals while the apparatus is in operation in response to the pressure created in the respiration chamber when filling the same with oxygen and the elimination of pressure in this chamber when the oxygen is withdrawn from the respiration chamber.

Various means may be employed for connecting the toggle members with the intake valve 17 so that the latter is opened and closed as the line passing through the point of connection between opposite ends of the snap spring and the toggle members moves from one side to the other of the dead center represented by the fulcrum 29 of the toggle members. It is preferable, however, to employ for this purpose a shifting rod 33 which has one of its ends connected with the lower arm 26 of the elbow lever while its opposite end is connected with a shifting arm 34 projecting laterally from the outer toggle member 30, as shown in Figs. 2, 3, 7 and 8.

By these means the intake valve 17 will be opened when the toggle members are folded outwardly, as shown in Figs. 2 and 7, and closed when these toggle members are folded inwardly, as shown in Fig. 8.

In the absence of any pressure to deflect the toggle members inwardly into a position which would close the intake valve 17, these toggle members are moved into an outwardly folded position by an opening spring 35 which has its inner end connected with a pin 36 mounted on the inner toggle member 31, as shown in Fig. 4, while its outer end is connected with the stationary wall 24 of the respiration chamber by adjustable tension means whereby the outward pull on the inner toggle member for causing the same to fold outwardly and open the intake valve 17 may be adjusted as required. These adjusting means, as best shown in Figs. 2 and 3, preferably include an adjusting spring 37 of leaf form which has one of its ends connected with the wall 24 and its opposite end connected with the outer end of the toggle operating spring 35, and an adjusting screw bolt 38 connecting the intermediate part of the adjusting spring 37 with said wall 24. The combined resilience of the toggle spring 35 and the leaf spring 37 exert a constant outward pull on the inner toggle member which tends to fold the toggle members in the direction for opening the intake valve 17, and the tension of these springs may be regulated by turning the adjusting bolt 38 from the exterior of the housing in the required direction.

Turning of the toggle members so that the same fold inwardly or in a direction which will cause the intake valve 17 to close is effected by means which are responsive to a gas pressure within the respiration chamber having reached a predetermined degree. These pressure response means are preferably constructed as follows:

The numeral 39 represents a flexible disk-shaped diaphragm which extends across an opening 40 in that side of the body 10 opposite the wall 24 and has its edge secured to the adjacent circular outer side of the body around said opening so that this diaphragm forms a flexible wall of the respiration chamber which is exposed on its inner side to the pressure of gas within this chamber while its outer side is exposed to atmospheric pressure. This diaphragm is protected from injury by a perforated guard cap 41 which slides onto the periphery of the body 10 around the diaphragm opening 40 thereof, as shown in Figs. 1, 3 and 4.

6

Motion is transmitted from this diaphragm by a shifting link or arm 42 secured to the central part of the inner side of the diaphragm and projecting inwardly therefrom and having its inner end pivotally connected by a pin 43 with the inner toggle member 31, as shown in Figs. 2, 3, 4, 7 and 8.

Assuming that the pressure within the respiration chamber is low and that the diaphragm has been moved inwardly by atmospheric pressure so as to fold the toggle members outwardly and open the intake valve 17, as shown in Figs. 3, 4 and 7, oxygen under pressure would flow from the supply source into the respiration chamber and gradually increase the pressure within the same as the volume of gas therein increases.

The combined resistance of the toggle operating spring 32, the opening spring 35 and the adjustable spring 37 is such that they hold the diaphragm 39 in an inwardly contracted position shown in Figs. 3 and 4 until a gas pressure has been built up in the respiration chamber to the desired degree, say a pressure equal to a height of 8 inches of water and then the resistance of these spring means is overcome and the diaphragm is moved into an outwardly expanded position, whereby the toggle members are moved inwardly by the pull of the diaphragm until the toggle members have passed the dead center or axis of the pivotal connection between the same after which the snap spring 32 quickly completes the inward folding movement of the toggle members and closes the intake valve 17 so the inflow of oxygen into the respiration chamber for that cycle is arrested.

As the oxygen is withdrawn from the respiration chamber by inhalation of the person wearing the face mask the pressure within this chamber lowers and when this pressure has decreased to such an extent that the atmospheric pressure, together with the pull of springs 35 and 37, predominates and causes the diaphragm to be contracted or drawn inwardly and move the toggle members outwardly and when the latter have passed the dead center the snap spring 32 instantly assists in completing the outward folding movement of the toggle members, whereby the oxygen intake valve 17 is opened.

By the use of the operating spring means, such as springs 35 and 37, a constant outward pull is exerted on the toggle mechanism which not only yieldingly resists the opening movement of the intake valve, but also serves to positively hold open this valve in case the apparatus becomes stalled, thus ensuring a supply of oxygen to the person being served notwithstanding any failure in the normal working of the apparatus.

Venting means are provided for automatically venting the respiration chamber to the outer atmosphere periodically which means operate in successive cycles varying in length depending on whether the person being served is unconscious and unable to assist in the venting operation or whether the person is conscious and able to assist in this operation. These venting means in their preferred form are constructed as follows:

The numeral 44 represents a main vent opening or port formed in the rigid wall 24 of the respiration chamber and leading from the interior of the latter to the external atmosphere. On its outer side this wall is provided around the vent port with an annular outwardly facing valve seat 45 which is adapted to be engaged by an exhalation valve 46 of disk form movable toward and from this seat for opening and closing the

vent port. This exhalation valve is made very light so that when the same is free it can be moved outwardly easily either solely by the pressure of the gas in the respiration chamber when the person being served is not breathing, or the combined gas pressure of the gas in the respiration chamber and that produced by the exhalation of the person being served, while conscious.

The exhalation valve is yieldingly held in its closed position by light spring means which are preferably adjustable and preferably comprise a main supporting spring 47 of leaf form connected at one end by a screw 48 with the outer side of the wall 24 and having its opposite end bearing against the outer side of the exhalation valve and provided with an opening 49 which receives an outwardly projecting boss 50 on the exhalation valve, as shown in Figs. 4, 5 and 6. The resistance of the spring means which yieldingly hold the exhalation valve in its closed position may be regulated to suit requirements by means of an auxiliary leaf spring 51 secured at one end to the wall 24 by the screw 48 and bearing at its opposite end against the outer side of the central part of the main spring 47 and an adjusting screw 52 threaded into the wall 24 and bearing with its head against the auxiliary spring 51 between the ends thereof. By tightening or loosening the screw 52 the tension of the main and auxiliary springs 47 and 51 may be increased or decreased.

The exhalation valve is provided in its central part with a main bleed opening 53, the outer end of which is surrounded by an annular valve seat 54. Outside of the exhalation valve 46 is arranged a bleed valve 55 which is movable toward and from the seat 54 for opening and closing the bleed opening 53. This bleed valve is mounted on the outer end of a valve stem 56 which passes loosely through the bleed opening 53 and has its inner part guided on the bracket 23 and its inner end arranged to be engaged by a tappet 57 projecting laterally from the outer toggle member 30 on the inner side of its axis 29, as shown in Figs. 2, 3, 4 and 7. The bleed valve is yieldingly held in engagement with the seat 54 for closing the bleed opening by spring means which preferably comprise a main leaf spring 58 one end of which is secured to the outer side of the wall 24 by a screw 59 while its opposite end bears against the outer side of the bleed valve and is provided with an opening 60 which receives the outer end of the valve stem. Along the outer side of the main leaf spring 58 is arranged an auxiliary leaf spring 61 which is secured at one end to the wall 24 by the screw 59 and bears at its opposite end against the main spring 58 between the ends thereof. The tension of these springs can be adjusted by an auxiliary adjusting screw 62 having a threaded connection with the wall and bearing with its head against the outer side of the auxiliary adjusting spring, as shown in Fig. 5. Upon turning the screw 62 in one direction or the other the springs 58, 61 will be strained more or less and vary the resistance to the opening of the bleed valve and the exhalation valve accordingly.

While the diaphragm is contracted or moved inwardly the toggle members are in a position in which the exhalation valve 46 closes the main vent opening 44 in the housing wall 24 and the bleed valve 55 closes the bleed opening 53 in the exhalation valve, these valves being held shut by the combined resistance of their respective closing spring means, as shown in Figs. 5

and 6. At this time the main intake valve 17 is open admitting oxygen under a slight pressure into the respiration chamber, and if during this time the person being served is capable of breathing, then some of the oxygen will be inhaled from the respiration chamber and sustain the life of this person naturally. If, however, the person is unconscious and unable to breathe, then oxygen under pressure will be forcibly delivered from the respiration chamber into the lungs of the person being served. As oxygen is delivered either naturally or artificially from the respiration chamber to the lungs of the person being served, the combined resistance of the toggle return spring 35 and the spring means associated with the exhalation valve 46 and the bleed valve 55 operate to hold these valves shut and to resist the outward movement or expansion of the diaphragm so as to permit the pressure in the respiration chamber to build up to a predetermined limit.

While this pressure is gradually building up in the respiration chamber the diaphragm effects the first part of its outward or expanding movement without opening the exhalation and bleed valves, but the toggle trip mechanism is actuated, and when the toggle members have been moved inwardly beyond the dead center of the snap spring connection between the same this inward folding movement, as before described, is quickly completed, thereby permitting the intake valve 17 to be closed and the tappet 57 of the outer toggle member 30 to engage the valve stem 56 and move the latter outwardly and thus open the bleed valve 55 without, however, opening the main exhalation valve 46.

When this occurs the bleed opening or port 53 is opened and permits the oxygen to gradually escape from the respiration chamber solely through this port if the person being served is unable to breathe, and when the pressure in this chamber has been lowered to a certain point the return spring 35 operates to contract or draw the diaphragm inwardly and operate the toggle mechanism so as to again close the bleed opening 53, thereby beginning another operation of automatically feeding oxygen to the respective person. Like cycles of these operations are repeated successively and continuously so long as the apparatus is in use, during each of which cycles oxygen is positively fed to the lungs of the person and then permitted to discharge to the outer atmosphere.

If, however, the person being served is breathing, although unconscious, an inhalation of the lungs will cause oxygen to be drawn from the respiration chamber into the lungs and during an exhalation of the lungs the spent gas will be discharged into the respiration chamber and from thence be discharged through the vent port 44 to the atmosphere, inasmuch as the exhalation valve at this time is relieved from the pressure of the auxiliary springs 58, 61 and the resistance of the springs 47, 51 is so light that the pressure during such exhalation can easily open the exhalation valve. Assistance of the person being served in the operation of this apparatus is perceptible even though the breathing of the person is very low and in actual experience an exhalation of one-quarter inch water pressure has been found helpful.

When this apparatus operates to supply oxygen to a person who does not assist by breathing, the duration of the cycles of operations is comparatively long and slow, but if the person

is breathing and assisting the apparatus the duration of the cycles of operation is shorter and more rapid. The normal period of the breathing cycles of a person is usually between 12 and 20 inhalations and expirations per minute. In the assembling of this apparatus the same has been timed to effect about 5 to 10 cycles of operations per minute and this has proven satisfactory in supplying sufficient oxygen to revive persons unable to breathe and then completing the restoration after such revival.

In order to enable this apparatus to be used most effectively by aviators at different altitudes or under other conditions which may vary, it is desirable to adjust the mechanism so as to vary the duration or cycle of operations to suit particular requirements or conditions. Adjusting means have therefore been provided whereby the period or length of each cycle of the operations of this apparatus may be regulated.

Inasmuch as some exhalation or venting of the respiration chamber is necessary in each cycle of operations the main exhalation and bleed valves 46, 55 are utilized in the present construction for effecting the minimum venting of the respiration chamber and these valves therefore have been designed to produce a fixed or definite amount of ventilation which is never disturbed or changed.

For the purpose of enabling the speed or duration of the automatic cycles of operations to be adjusted to suit requirements, the amount of venting which is done above that furnished by the valves 46, 55 is accomplished by means which are preferably constructed as follows:

The numeral 63 represents a valve plug screwed into a threaded opening in the upper part of the circumferential wall of the housing and provided with an auxiliary bleed port or opening 64 which extends from the interior of the respiration chamber to the exterior of the instrument and which is provided at its inner end with an inwardly facing annular valve seat 65 and between its ends with an outwardly facing valve seat 66, as shown in Fig. 3. Into the outer part of the plug 63 is screwed a valve stem 67 which is provided at its inner end with a regulating valve 68 adapted to be adjusted toward and from the outer valve seat 66 for varying the size or capacity of the port 64 by turning this valve through the medium of a knob 69 arranged on the outer end of this stem. After the regulating valve 68 has been adjusted into the desired position relative to the seat 66, the same is held against movement by a detent device consisting preferably of a detent spring 70 secured between the housing and the plug 63 and bearing frictionally against a groove 71 in the knob 69. Communication between the outer part of the bleed opening 64 and the external atmosphere is permanently established by one or more bypass openings 72 arranged lengthwise in the valve stem 67.

The numeral 73 represents an auxiliary bleed valve which is movable toward and from the inner valve bleed seat 65 for closing and opening the auxiliary bleed opening 64. This auxiliary bleed valve is secured to a valve stem 74 which is guided at its outer end in an axial opening 75 in the regulating valve 68 and has its inner end connected by a link 76 with the rock arm 34 of the outer toggle member 30. The auxiliary bleed valve 73 is yieldingly held in its closed position by a spring 77 which preferably has the form of a leaf secured at one end to the inner side of the body or housing 10 and bearing with its opposite

free end against the inner side of the auxiliary bleed valve, as shown in Figs. 1 and 3.

This auxiliary bleed valve 73 controlling the adjustable bleed port 64 and the main bleed valve 55 controlling the non-adjustable bleed port 53 are closed and opened in unison by the mechanism which actuates them so that communication between the respiration chamber and the outer atmosphere is cut off during the initial part of the expanding movement of the diaphragm while oxygen under pressure is entering the respiration chamber and the toggle members have moved inwardly from their outwardly folded position to a point past the dead center of this toggle mechanism, which movement of the parts is additionally resisted by the return spring 35 and thus causes an increase in pressure of the gas to be built up within the respiration chamber beyond that which would exist if such additional resistance were omitted. After the toggle members during this inward movement have passed the dead center 29 of this mechanism, the resilience of the toggle spring 32 assists the pressure of the incoming gas against the diaphragm so as to quickly complete the expanding movement of the latter as well as completing the charge of gas which is admitted during this cycle of operations.

During the time that oxygen is entering the respiration chamber and accumulating therein, some of the oxygen is forcibly delivered from the feed outlet 16 to the person being served without any assistance from the latter, if this person fails to breathe and thus maintains the function of the lungs until normal breathing has been restored. If, however, the person is not wholly unconscious or breathing slightly, this action of the person's lungs will assist the operation of the apparatus in supplying sufficient oxygen to maintain life and effect ultimate recovery of the full function of the lungs. As the diaphragm is completing its expanding movement both the main and auxiliary bleed valves 55 and 73 are opened automatically, thereby permitting the oxygen to escape slowly through the bleed ports 53 and 64 from the respiration chamber to the atmosphere together with any exhalation from the lungs of the person being served. This cycle of operations is repeated continuously and automatically while the apparatus is in use. When the main bleed valve 55 is open the exhalation valve 46 is relieved from the pressure of the spring means associated with the main bleed valve and thus permits the exhalation valve to be opened easily by the exhalation pressure of the person being served for effecting venting of the spent gas.

By adjusting the regulating valve 68 the rate of bleeding or discharge of gas from the respiration chamber can be adjusted and thus vary the duration of each cycle of operations and the speed of the automatic action to suit the requirement of different conditions.

From the foregoing it will now be clear that this apparatus positively feeds oxygen to a person who is helpless due to failure of the breathing organs and that no negative pressure or suction is exerted on such person at any time, thereby aiding the person in recovering the breathing function without creating any unfavorable condition or possible injury to the person which might occur if the lungs of the same were subjected to a suction effect.

Although this device may be used for therapeutic treatments, the same was devised more primarily for use at high altitudes because a man has a very low oxygen tolerance at high altitude

with the result that if he should become separated from his oxygen supply for, say, even a minute he loses the necessary power in that brief time to connect a breathing equipment with a source of oxygen supply so that he quickly becomes unconscious and becomes the responsibility of the rest of the crew to revive him by an oxygen supply.

It is exceedingly difficult to give artificial respiration to a victim at high altitude and it is therefore necessary, in order to obtain ventilation of the lungs, to put this oxygen into the man under a slight positive pressure. In the operation of this apparatus pressure is built up inside the lungs and then allowed to decrease so that there is an exchange or total change of air in proportion to the size of the man's lungs, for example, at 8 inches of water pressure. It is then permitted to drop to a predetermined low of one-quarter of an inch of water pressure. Providing the man makes no effort himself the device will automatically increase the pressure again to the 8 inches. When it reaches that 8 inches it will again return to the critical low pressure of one-quarter of an inch. That cycle is repeated automatically between 6 and 10 times per minute which is sufficient to maintain life. If, however, the user starts to regain consciousness or he should make any inspiratory effort whatsoever he supplies oxygen himself. From the physiological angle, a man's first effort is always an inspiration. Any effort he should make along that line the present device will automatically follow. The automatic cycle relaxes the moment he helps himself and the device follows rather than exerts a treatment of its own. A man's normal breathing is between 12 and 20 times per minute. If any time a man should fail to breathe with that regularity or the cycle should become less than that and down to this lower frequency, say between 6 and 10, this device automatically starts to function.

This device is primarily designed to overcome anoxemia, that is, a shortage of oxygen due to any cause. The causes are numerous at high altitude. Sudden excitement will cause a man to exceed his oxygen tolerance. For instance, if a man were in the mid part of an airplane and a man along side of him is shot, the excitement of that incident might so increase the other man's functions that he might pass out too.

At ground level a man requires approximately a reserve supply of oxygen to the extent of about 600 cubic centimeters of oxygen. The rate of consumption of oxygen by a man is between 3 to 500 cubic centimeters per minute so that on the ground a man has an oxygen tolerance of only a few minutes. At high altitude the tolerance becomes much less until at altitudes, for example, 35,000 feet, his oxygen tolerance is considered to be less than 35 seconds. If a man at an altitude of 35,000 feet has his apparatus disconnected from his source of oxygen for a period of between 30 and 60 seconds he no longer has the strength to reconnect that apparatus. At altitudes of 40,000 feet that is even less possible. It has been estimated that 15 to 20 seconds discontinuance of oxygen to a man is practically the extreme limit if life is to be maintained.

In case some member of a flying party or crew should become incapacitated while detached from the source of oxygen supply it becomes the duty of some other member of the crew to take his station and attach this equipment to the helpless man and from there on this apparatus will operate automatically. The device functions auto-

matically while the person is unconscious and when the man regains consciousness the device automatically follows his breathing and makes up any deficiency in oxygen supply.

In practice it is planned to equip each airplane with a plurality of units embodying this invention and place them at strategic points throughout the airplane and so organize the present oxygen equipment now in the airplane or make slight modifications in the emergency oxygen equipment now on the airplane that the present invention can be quickly coupled thereto and form a part thereof as an accessory.

A portable oxygen supplying equipment, known as "walk-about" units, has been used heretofore in case of emergency. This emergency equipment is used by the personnel when they walk about the ship to perform any details to which they may be assigned. If, for any reason, he has to leave his station he uses this emergency equipment. In order to gain the advantages of the present invention the same is added to or coupled with the emergency equipment already in the plane.

In order to make this emergency equipment or "walk-about" including the oxygen supply bottles in the ship usable in connection with the present invention, means are employed for transferring the oxygen at an increased pressure from the emergency equipment to the present equipment. Any suitable means may be employed for obtaining this increased gas pressure.

Another function which the device of this invention performs is that it will maintain useful consciousness of a person at altitudes beyond 42,000 feet. Experimental flights have been maintained by persons using this invention at an altitude of 50,000 feet which are impossible with ordinary oxygen equipment. When using equipment heretofore on the market, a man would inhale oxygen at the barometric pressure of the respective altitude. The equipment embodying the present invention renders it possible for a man to inhale oxygen at a pressure greater than barometric pressure. It permits a greater and more complete ventilation of the lung and the greater efficiency of this invention at high altitude makes possible a much higher ceiling when dealing with 8 inches of water pressure. The present ceiling of oxygen equipment is 42,000 feet, which is the highest practical ceiling so far. There have been experiments carried out with constant pressure and they have been able with constant pressure to attain altitudes of approximately 50,000 feet. That equipment is good to a certain point, but it has disadvantages inasmuch as the man inhales at a pressure of less, say normally 8 inches of water pressure, and he exhales at a pressure of 9 inches and this in a sense is fatiguing. In the device of the present invention a man on inspiration has a positive pressure of approximately 8 inches of water. On the completion of his inspiration the pressure rise to the top is about 8 inches and at that particular point the valve mechanism changes and the man exhales against a much lower pressure. In other words, the valves are open to the atmospheric pressure and the result is that the man gets aid on inhalation and there is a comparatively free exhalation. As a result the man is less fatigued when using the present equipment.

The present resuscitator differs from other types of resuscitators on the market in that the present resuscitator employs a positive pressure at all times, while all other devices of this char-

acter first operate with a positive pressure and then with a negative pressure.

At ground level this device can be used with either oxygen or atmospheric air or a mixture of both. The device may be supplied with a low pressure source of gas which may be either pure oxygen or atmospheric air or a mixture of atmospheric air and oxygen or any other gas that may be desirable to stimulate or aid a person. It has been known that in some cases carbon dioxide helps stimulate certain nerve centers and causes a more rapid recovery. Administering carbon dioxide can be readily effected by this device.

Another important use of this instrument is for treating pulmonary edema which is a filling up of the lungs with mucous resulting from pneumonia brought on by the irritating effect of war gases. One of the war gases "phosgene" becomes hydrochloric acid from which the patient eventually dies by drowning. The only successful method of treating various forms of pulmonary edema is with the use of positive pressure. Continuous positive pressure alone is fatiguing and difficult on a patient but the present device operating intermittently with a positive pressure greatly reduces resistance on exhalation and makes possible an easy and complete cure.

In the use of positive pressure it is important that the positive pressure be not too great because it causes what is known as "emphysema," that is, a rupturing of the lung and stomach tissue and permitting air to enter other parts of the system.

The normal cycle of a breathing operation between 12 and 20 times per minute, can be maintained with between 4 and 5 respirations per minute. The ideal maximum pressure for ground work is 13 centimeters of water pressure.

From the foregoing it will be evident that the apparatus of this invention permits of supplying adequate oxygen to persons at altitudes above 42,000 feet, it can also be used as an emergency resuscitation apparatus, and it can also be used at ground level for general resuscitating purposes and also for administering other gas to persons for therapeutic purposes.

I claim as my invention:

1. A breathing apparatus comprising a respiration chamber having an intake for gas under pressure, a service opening adapted to be connected with the person being served and a vent leading to the outer atmosphere, inlet valve means which control said intake and which include an intake valve seat arranged around said intake, a valve movable toward and from said intake seat, a diaphragm which is responsive to variations in pressure in said chamber, and means for transmitting motion from said diaphragm to said valve including a toggle mechanism having two toggle members which are adapted to fold relative to each other alternately on opposite sides of the dead center of said toggle mechanism, a link connecting one of said toggle members with said diaphragm, and an intermediate elbow lever having one of its arms connected by a shifting rod with the other toggle member and having its other arm connected by a shifting rod with said valve.

2. A breathing apparatus comprising a respiration chamber having an intake for gas under pressure, a service opening adapted to be connected with the person being served and a vent

leading to the outer atmosphere, inlet valve means which control said intake and which include an intake valve seat arranged around said intake, a valve movable toward and from said intake seat, a diaphragm which is responsive to variations in pressure in said chamber, and means for transmitting motion from said diaphragm to said valve including a toggle mechanism having two toggle members which are adapted to fold relative to each other alternately on opposite sides of the dead center of said toggle mechanism, a link connecting one of said toggle members with said diaphragm, an intermediate elbow lever having one of its arms connected by a shifting rod with the other toggle member and having its other arm connected by a shifting rod with said valve, and a return spring whereby said toggle members are turned in a direction opposite to the pull of said diaphragm.

3. A breathing apparatus comprising a respiration chamber having an intake for gas under pressure, a service opening adapted to be connected with the person being served and a vent leading to the outer atmosphere, inlet valve means which control said intake and which include an intake valve seat arranged around said intake, a valve movable toward and from said intake seat, a diaphragm which is responsive to variations in pressure in said chamber, and means for transmitting motion from said diaphragm to said valve including a toggle mechanism having two toggle members which are adapted to fold relative to each other alternately on opposite sides of the dead center of said toggle mechanism, a link connecting one of said toggle members with said diaphragm, an intermediate elbow lever having one of its arms connected by a shifting rod with the other toggle member and having its other arm connected by a shifting rod with said valve, a return spring whereby said toggle members are turned in a direction opposite to the pull of said diaphragm, and a detent spring connected with said toggle members and yieldingly holding them in a folded position on one side or the other of said toggle mechanism.

4. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening for communication with the person to be served and means for venting said chamber to the outer atmosphere including a main vent port formed in a wall of said chamber, a main valve controlling said main port and provided with a bleed opening, a bleed valve controlling said bleed opening, spring means for yieldingly holding said main valve in its closed position, spring means for yieldingly holding said bleed valve in its closed position and also aiding in holding said main valve shut, and operating means which are responsive to the pressure of the gas in the chamber and which operate to open said bleed valve independently of said main valve.

5. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening for communication with the person to be served and means for venting said chamber to the outer atmosphere including a main vent port formed in a wall of said chamber, a main valve controlling said main port and provided with a bleed opening, a bleed valve controlling said bleed opening, spring means for yieldingly holding said main valve in its closed position, spring means for yieldingly holding said

bleed valve in its closed position and also aiding in holding said main valve shut, and operating means which are responsive to the pressure of the gas in the chamber and which operate to open said bleed valve independently of said main valve, each of said spring means including a main leaf spring engaging the respective valve, an auxiliary leaf spring engaging the main leaf spring, and an adjusting screw engaging the auxiliary leaf spring.

6. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening for communication with the person to be served and means for venting said chamber to the outer atmosphere including a main vent port formed in a wall of said chamber, a main valve controlling said main port and provided with a bleed opening, a bleed valve controlling said bleed opening, spring means for yieldingly holding said main valve in its closed position, spring means for yieldingly holding said bleed valve in its closed position and also aiding in holding said main valve shut, and operating means which are responsive to the pressure of the gas in the chamber and which operate to open said bleed valve independently of said main valve, said operating means including a valve stem connected with said bleed valve, a diaphragm responsive to the pressure of gas in said chamber, and means for transmitting motion from said diaphragm to said valve stem including toggle members which are foldable relative to one another alternately on opposite sides of the dead center of these members, a link connecting one of said toggle members with said diaphragm, and a tappet arranged on the other toggle member and adapted to engage said valve stem.

7. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening adapted to communicate with the person being served, and means for venting said chamber including a vent port leading from said chamber to the outer atmosphere and having an inner control valve seat and an outer regulating valve seat, a valve plug screwed into the outer part of said port and having a regulating valve movable toward and from said regulating valve seat and also provided with a bypass opening, a control valve movable toward and from said control valve seat, a valve stem carrying said control valve and guided on said valve plug, and actuating means which are responsive to increase and decrease of pressure in said chamber and which are connected with said valve stem.

8. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening adapted to communicate with the person being served, and means for venting said chamber including a vent port leading from said chamber to the outer atmosphere and having an inner control valve seat and an outer regulating valve seat, a valve plug screwed into the outer part of said port and having a regulating valve movable toward and from said regulating valve seat and also provided with a bypass opening, a control valve movable toward and from said control valve seat, a valve stem carrying said control valve and guided on said valve plug, and actuating means which are responsive to increase and decrease of pressure in said chamber and which are connected with said valve stem including a toggle mechanism one

member of which has an arm operatively connected with said valve stem.

9. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening having means for connection with a person to be served, and a vent leading from said chamber to the outer atmosphere; and a valve device for controlling said vent which is responsive to pressure variations in said chamber and which includes a non-positively operating exhalation valve adapted to open said vent and having a bleed opening, a positively operated bleed valve which is adapted to open said bleed opening, spring means for directly holding said exhalation valve yieldingly in a closed position, and spring means for directly holding said bleed valve yieldingly in a closed position and indirectly assisting in holding said exhalation valve yieldingly in a closed position.

10. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening having means for connection with a person to be served, and a vent leading from said chamber to the outer atmosphere; and a valve device for controlling said vent which is responsive to pressure variations in said chamber and which includes a non-positively operating exhalation valve adapted to open said vent and having a bleed opening, a positively operated bleed valve which is adapted to open said bleed opening, spring means for directly holding said exhalation valve yieldingly in a closed position, and spring means for directly holding said bleed valve yieldingly in a closed position and indirectly assisting in holding said exhalation valve yieldingly in a closed position, and said exhalation valve being openable independently of said bleed valve after the latter is opened.

11. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening adapted to be connected with a person to be served, and a vent leading from said chamber to the outer atmosphere, actuating means which are responsive to variations of pressure in said chamber, and a valve device for controlling said vent including a positively operated bleed valve which is shifted by said actuating means, and a non-positively operated valve which is actuated by the exhalation of the person being served.

12. A breathing apparatus comprising a chamber having an intake for gas under pressure, a service opening adapted to be connected with a person to be served, and a vent leading from said chamber to the outer atmosphere, actuating means which are responsive to variations of pressure in said chamber, and a valve device for controlling said vent including a non-positively operating exhalation valve adapted to be opened by the exhalation of the person being served and having a bleed opening, and a positively operated bleed valve which is moved by said pressure responsive actuating means for opening said bleed opening.

13. A breathing apparatus comprising a chamber having a gas intake, a service opening which is open constantly and adapted to communicate with the person being served, and venting means leading from said chamber to the outer atmosphere, actuating means which are responsive to variations in pressure in said chamber, manually adjustable valve means for controlling a part of said vent means, and non-adjustable valve means which control another part of said valve means

and are moved by said pressure responsive actuating means.

14. A breathing apparatus comprising a chamber having a gas intake, a service opening which is open constantly and adapted to communicate with the person being served, and venting means leading from said chamber to the outer atmosphere, actuating means which are responsive to variations in pressure in said chamber, manually adjustable valve means for controlling a part of said vent means, non-adjustable valve means which control another part of said valve means and are moved by said pressure responsive actuating means and intake valve means which control the intake of said chamber and which are moved by said pressure responsive actuating means.

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